SUBMISSION TO THE ROYAL SOCIETY OF CANADA

COMMISSION ON LEAD IN THE ENVIRONMENT

PRESENTED BY THE

NEW BRUNSWICK

DEPARTMENT OF MUNICIPAL AFFAIRS AND ENVIRONMENT

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BATHURST

SUMMARY

The New Brunswick Department of Municipal Affairs and Environment (DMAE) has conducted a variety of monitoring surveys which include evaluation of lead concentrations in the province. In this submission, a description of the lead information available from the Department, sources of information and a few examples of data will be presented.

The Department's lead data include information regarding air quality, industrial effluents, sanitary wastes, drinking water, surface water quality and uptake by biota. This information is mostly concentration data, with little or no assessment of actual impacts.

The available monitoring data identify the Belledune lead smelter, Brunswick #12 Mine, Heath Steele Mine, combustion of leaded gasoline, sewage sludges, and burning of waste oil as sources of lead released to the environment. Two other sources, lead-rich dust escaping from railcars carrying ore from Brunswick Mines to Dalhousie, and spillage of ore and concentrate at the Dalhousie loading facility, have also been monitored.

The information available from monitoring surveys, however, is not sufficient to provide perspective concerning the volumes of lead produced by sources in the province. By using the lead generation factors suggested in the Environmental Protection Service (EPS) report entitled National Inventory of Sources and Releases of Lead (1982), and existing monitoring data, it is possible to estimate the relative contributions from major sources.

TABLE I MAJOR SOURCES OF LEAD IN NEW BRUNSWICK (ESTIMATED)

Source	EPS(1982) kg/yr	DMAE kg/yr
1) Fugitive Emissions from mining and milling operations	281,000	180,000('84)
2) Lead emissions from gasoline-powered motor vehicles	170,000	-
3) Lead Smelting (air emissions)	59,000	59,000('84) 90,000('85)
4) Industrial Effluents	38,000	2,000('85)

EPS Estimates (after A. P. Jaques, 1985), see Appendix I;

DMAE Estimates - calculated using EPS generation factors/N. B. mineral production figures (B. M. W. Carroll, 1985), and BM&S/ Heath Steele monitoring data

It should be noted that the estimates for fugitive emissions are only an approximation of the actual volume of lead emitted from mining and milling sources. It is also important to consider the form of the lead released in determining the relative effects of the lead emitted. For example, the fugitive emissions from mining and milling operations are released as lead sulfide which is very stable. The lead emissions from combustion of leaded gasoline (tetraethyl lead), and lead smelting (elemental lead) are much more reactive and unstable than lead sulfide.

The differences in the EPS(1982) and DMAE(1984-85) figures are, in part, attributed to changes in emissions and effluents. The 1984 fugitive emissions were lower than the 1982 estimates because two of the lead producing mines shut down during this period. The difference in industrial effluents is due to variation in the effluent quality from the Brunswick #12 Mine:

33,000 kg Pb/yr in 1982,
8,600 kg Pb/yr in 1983,
1,300 kg Pb/yr in 1984, and
600 kg Pb/yr in 1985.

These values are from an EPS analysis of effluent data reported by Brunswick Mining & Smelting (BM&S) (George Lindsay, personal communication).

Air quality monitoring has revealed background levels of lead in the atmosphere ranging from 0.03-0.08 $\mu g/m^3$. Routine measurement of total suspended lead in Saint John has shown decreasing concentrations which may be associated with the decrease in the use of leaded gasoline. No specific studies regarding the levels of airborne lead associated with the use of leaded gasoline have been carried out in New Brunswick.

The Belledune Lead Smelter, a major source of airborne lead in New Brunswick, emits approximately 59,000 kg/year(1984). Its lead emissions for 1985 were 90,000 kg/yr (BM&S data). The increase in lead emissions may be attributed to problems with baghouse operations and/or to the use of limited stack sampling results which may not accurately represent smelter emissions. Several studies, conducted by Brunswick Mining & Smelting, and the Department have shown that the highest lead concentrations in the Belledune area are located within a 3 km radius of the smelter, however, no adverse effects have been documented. Burning of waste crankcase oil, which generally contains 1000-3000 ppm lead, has also caused concern that higher than desirable levels of lead will be released to the atmosphere. Elevated lead levels from ore and concentrate dust have been monitored along the railway route from Brunswick #12 Mine to Dalhousie. In 1984, Brunswick Mining & Smelting implemented measures to limit dust escaping from railcars.

Natural surface waters and municipal water sources have lead values of less than 0.05 mg/l, within the Canadian Drinking Water

Guidelines established by the federal Department of Health and Welfare. Surface waters downstream of the Brunswick Mines, and the Heath Steele Mine contain above-background concentrations of lead. In recent years, the Brunswick #12 Mine and the Belledune lead smelter have significantly reduced the concentration of lead in their effluents. Measures have also been implemented by Brunswick Mining to reduce lead and particulary cadmium contamination of sediments near the Dalhousie loading facilities.

Recent effluent monitoring (1985) indicates that Brunswick #12 Mine discharges 1242 kg lead/year, and the Heath Steele Mine discharges 356 kg lead/year. These effluents are generally within the federal/provincial limits for lead (0.2 mg/l).

The Belledune Lead Smelter releases 183-250 kg lead/year (DMAE,1985, and L. Hildbrand, 1984) in its liquid effluent. Due to the high concentration of heavy metals discharged from the smelter prior to 1981 (8,330 kg/year, L. H. Hildebrand, 1984), the waters, sediment and marine biota of the Belledune Harbour and surrounding area contain significantly elevated concentrations of lead and other heavy metals. The heavy metal contamination of this area has been decreasing since the installation of an effluent treatment facility in December 1980. Marine data for the smelter area has been gathered by Brunswick Mining & Smelting, the federal Department of Fisheries and Oceans, and the Environmental Protection Service.

Sewage treatment plant effluents are occasionally monitored for lead. Results indicate the presence of very low concentrations. However, sewage sludges have lead levels which may be significant when sludges are used for agricultural purposes.

The levels of heavy metals in mosses and lichens have been monitored to determine the accumulation and deposition rates of airborne heavy metals to vegetation in certain areas of the province (J. Tims, 1986). Lead concentrations in lichens and mosses in rural New Brunswick are elevated with respect to lead levels in arctic lichens and mosses. Lead levels exceeding rural values have been measured in the vicinity of Saint John, Dalhousie and Belledune. Substantially elevated lead levels in lichens in the vicinity of Belledune have been attributed to airborne emissions of the lead smelter. Elevated lead levels in other areas are probably due to emissions from the utility, industry and transportation sectors.

INDUSTRIAL EFFLUENTS

Since 1975, the main industrial effluents contributing lead to the environment have been from the Brunswick #12 Mine, the Heath Steele Mine, and the Belledune Lead Smelter. For 1985, the total lead discharged in liquid effluents from these sources was in the order of 1781 kg; 1242 kg/year from the Brunswick #12 Mine, 356 kg/year from the Heath Steele Mine, and 183 kg/year from the Belledune Smelter. Ore and concentrate spillage at the Dalhousie loading facility has, in the past, contaminated sediments in the area.

The province has adopted the federal limit of 0.2 mg/l for regulating lead concentrations in mining effluents, and 0.3 mg/l for the effluent from the Belledune Smelter. The mining and smelting industries of New Brunswick are generally in or near compliance with these limits.

TABLE 2 INDUSTRIAL EFFLUENTS CONTAINING LEAD

Source	Flow (mld)	Pb (mg/l)	Comments
Heath Steele (mine not operating)			
Tailings pond overflow	8.64	0.113	precipitation affects flow
Little S. Tomogonops R.	-	>0.020	separate discharge
Brunswick #12 (mine operating)			
Final Effluent	16.2	0.21	(mean - 0.1 mg/l)
Mouth of S. Little R.	-	0.13	downstream of effl.
Mouth of Little R. at Bathurst	-	0.16	downstream of effl.
Brunswick #6 (mine not operating)			
Knight's Brook at Confluence	-	>0.10	downstream of mine
BM&S Lead Smelter			
Final Effluent	2.0	0.25	(Pb limit, 0.3 mg/l)
Federal/Provincial Limits	-	0.2	Metal Mining Liquid Effluent Regs and Guidelines, EPS, 1977

mld - million liters per day
(Information from 1985 Annual Averages - Company Data)

Available data include company reports (usually 4 per month), Department monitoring results (1-2 surveys per year), and EPS

monitoring data (one survey per year). This type of information is available for most mines which were operating after 1970. Some pre-1970 data are also available. Valuable historical data may be found in the Canada-New Brunswick Northeastern New Brunswick Mine Water Quality Program Report prepared by Montreal Engineering Company Limited (1972). EPS has gathered data concerning heavy metal contamination associated with the ore and concentrate loading area at Dalhousie.

The submission by the Belledune Environmental Monitoring Committee details the information available regarding lead concentrations in various substrates and biota from the area surrounding the Belledune Lead Smelter.

SANITARY WASTES

The Department measures lead concentrations of sewage treatment plant influents, effluents and sludges only in special cases. Therefore the information regarding lead concentrations of these wastes is limited. The following table provides a sampling of the available data.

TABLE 3 LEAD CONCENTRATIONS IN SANITARY WASTES

Location	Pb (mg/l)	Flow (mld)
Fairvale Lagoon Influent (1985)	.008-.010	1.93
St. Stephen Lagoon Influent (1985)	.009-.024	1.58
St. Stephen Lagoon Effluent (1985)	.016	1.58
Quispamsis Lagoon Influent (1985)	.006	0.79
Quispamsis Lagoon Effluent (1985)	.002	0.79
15-16 Waste Treatment Plants (1983)	>.5	-
Campbellton Treatment Plant Infl. (1984	.014	10.98
Campbellton Treatment Sludge (1984)	49.	(210-250 kg/day) (wet weight)

mld - million liters per day
(Information from DMAE survey results)

Although sewage treatment plant effluents have very low concentrations of lead, sewage sludges may contain significant levels. Heavy metal concentrations in sewage sludges will likely be examined in more detail in the future. At present, most waste treatment plant sludge is landfilled. However, some sludge is used by farmers as a soil amendment. In recent years, there appears to be an increase in the demand for sludge for agricultural uses.

DRINKING WATER

Each year, the Department surveys the quality of municipal drinking water sources for a variety of parameters including lead. The lead levels in municipal drinking water sources (wells and surface waters) are less than 0.05 mg/l.

Private wells are analysed upon request or during investigation of contamination problems. Very few results for private wells have exceeded the Canadian Drinking Water Guideline of less than 0.05 mg/l lead.

AIR EMISSIONS

The Department has conducted several surveys of airborne lead. These include monitoring of total suspended lead, monitoring of lead related to burning of waste oil, and auditing emissions from the Belledune lead smelter.

Total suspended lead in air has been monitored since 1974 at one station in Fredericton, and at five stations in Saint John. The annual results shown in the following table are calculated from sixty 24-hour samples per station. The Red Head station indicates background lead levels (0.11-0.03 $\mu g/m^3$), and the Police Station on Manawagonish Road, Saint John indicates levels near a highway (0.44 -0.08 $\mu g/m^3$). The trend of decreasing values may be attributed to decreased use of leaded gasoline.

TABLE 4 CUMULATIVE RECORD OF ANNUAL CONCENTRATIONS TOTAL SUSPENDED LEAD ($\mu g/m^3$; geometric means)

YEAR	Forest Hills	Red Head	Provincial Building	Mill'g -ville	Police Station	Fredericton Fire Station
1974	-	0.08	-	0.24	0.44	-
1975	-	0.11	0.46	0.33	0.41	0.76
1976	0.25	0.06	0.31	0.23	0.18	0.55
1977	0.18	0.04	0.23	0.12	0.14	0.42
1978	0.17	0.07	0.20	0.18	0.12	0.34
1979	0.18	0.04	0.21	0.19	0.11	0.39
1980	0.26	0.03	0.19	0.26	0.10	0.34
1981	0.24	0.05	0.20	0.21	0.11	0.34
1982	0.21	0.05	0.17	0.19	0.11	0.29
1983	0.15	0.03	0.12	0.11	0.08	0.24
1984	0.11	0.05	0.11	0.10	0.09	0.17

(DMAE Monitoring Results)

EPS (A. P. Jaques, 1985) has estimated that lead emissions from gasoline-powered vehicles are the second largest source of lead released to the environment in the province.

In a recent study in the Blacks Harbour area, the ambient air quality was monitored at a station 0.5 km from a site where waste oil was burned. Lead concentrations in the waste oil were approximately 1000 ppm.

TABLE 5 WASTE OIL BURNING, BLACKS HARBOUR, N. B. 1985 HI-VOLUME FILTER RESULTS

DATE		FILTER NUMBER	TSP µg/m3	LEAD µg/m3
May	1	1676	49	0.1
	3	1678	23	0.1
	6	1679	27	0.3
	7	1680	15	0.1
	9	1681	67	0.2
	10	1683	56	0.1
	13	1682	40	0.1
	15	1684	59	0.1
	16	1686	30	0.0
	17	1687	23	0.1
	21	1688	35	0.1
	23	1689	41	0.1
	24	1690	41	0.1
	28	1691	19	0.0
	29	1692	54	0.1
	31	1693	75	0.0
June	3	1694	52	0.1
	4	1695	31	0.0
	5	1696	90	0.6
	6	1697	29	0.1
	7	1698	23	0.1
	10	1699	36	0.1
	11	1700	55	0.2

TSP - total suspended particulate
(DNAE Monitoring Results)

The June 5 results, in particular, have raised some concern about the suitability of waste oil as a fuel source as the company records show only a small amount was burned that day. Apart from the concern with lead concentrations, it has been noted that some individuals who collect waste oil have included solvents in their batches. The future of waste oil products as fuels is under review by the Department.

Lead emissions from the Belledune Lead Smelter have been the subject of several studies by Brunswick Mining & Smelting, and government agencies. Company data and auditing data are available from the Department (see Appendix 2). Particulate in the vicinity of the Belledune smelter was monitored by BM&S from 1965 to 1984 at sixteen stations using dust bucket samplers; in 1984, three HiVol samplers were installed to replace the dust bucket samplers. Particulate and metal results for 1985 are presented in Appendix 2. The submission by the Belledune Environmental Monitoring Committee contains several references to other studies relating to smelter emissions.

The Department has not measured fugitive emissions from mining and milling operations. Using the lead generation factors established by EPS (Jaques, 1985), it appears that such emissions are the largest source of lead released to the environment in the province. EPS estimated such releases to be in the order of 281,000 kg/year during 1982. Since 1982, two of the lead producing mines have shut down. Using the generation factors, and 1984 provincial mineral production figures (73,250 tonnes of lead, B. M. W. Carroll, 1985) the fugitive emissions are estimated to be 180,000 kg/year.

Brunswick #12 Mine, the only lead producing mine operating at present, is carrying out studies to determine dusting rates and to develop a method of dust control. The Company hopes to limit the contamination of the area surrounding the mine tailings.

The province has established 120 micrograms particulate/m^3/24 hours as the limit for total suspended particulate in air. The limits of 5 micrograms lead/m^3/24 hours, and 2 micrograms lead/m^3/30 days are used as guidelines in assessing lead concentrations.

ENVIRONMENTAL QUALITY

The Department's Environmental Quality Section has conducted a variety of surveys which include consideration of lead concentrations in the environment. These surveys include baseline and assimilative capacity studies of lakes and rivers, study of pH effects on drinking water quality, and several bioindicator studies to determine the accumulation and deposition rates of airborne heavy metals to vegetation.

Since the late 1970's, heavy metals, including lead, have been routinely monitored during baseline surveys of surface waters in New Brunswick. For a normal baseline survey, a lake or stream is sampled four times during the summer months. Historically, metals analysis have been carried out on one or all of the sampling runs. Presently, metals analysis of surface waters has been reduced because there appear to be no significant concentrations of heavy metals. To date, approximately 70 lakes and 20 rivers have been surveyed. Such lakes have been surveyed one to three times,

and rivers one to four times.

The assimilative capacity water program has also included measurement of lead concentrations. This program is aimed at determining the effects of mining and industrial effluents, domestic waste, and/or agricultural operations on receiving waters.

Sampling under both programs has been scattered, but most has taken place in the southern half of the province.

Prior to November 1983, the Department's detection limit for lead in water was 0.1 mg/l. Since then it has been 0.002 mg/l. Lead results have usually been reported as extractable lead, and concentrations in surface waters have typically been near or below detection.

The New Brunswick Department of Forest, Mines and Energy has collected some information regarding metals concentrations in sediments. Other information on surface water quality and sediments may be available from the Inland Waters Directorate (Moncton), Fisheries and Oceans Canada (Halifax and Moncton), and the Environmental Protection Service (Halifax).

In 1978, 1980 and 1983, surveys were conducted along the railway from the Brunswick #12 Mine to Dalhousie to determine the deposition of metals caused by concentrate dust escaping from rail cars. Two snow surveys have indicated that the dust fallout is significant, and is heaviest within 32 meters (100 feet) of the tracks. In 1983, mean lead concentrations of 0.5 to 3.6 ppm were measured within this zone, compared to levels of 0.2 ppm in snow collected away from the tracks. Levels of both lead and zinc were statistically related to distance from the tracks.

Well water and foliage near the tracks were also sampled. In well water, concentrations of trace metals, including lead, were consistently within the Guidelines for Canadian Drinking Water Quality.

Lead and zinc concentrations in white spruce needles collected near the railway were frequently at or above values considered excessive for rural locations (50 ppm, Phytotoxicology: Excessive Levels for Contaminants - 1982, Ontario Ministry of Environment). Lead levels in the samples ranged from 17.3 to 275.1 ppm.

As of April 1984, a dust suppressant has been used by Brunswick Mining to help control the railcar dusting problem.

The Department has conducted several studies designed to determine patterns and levels of trace metal deposition to vegetation in the vicinity of point and area sources of airborne pollutants.

Results of a 1984 study indicated levels of lead in lichens and mosses in rural New Brunswick were elevated with respect to

levels in arctic lichens and mosses, perhaps due to long range transport of airborne lead. Lead levels in northern New Brunswick may be elevated in part due to the presence of geological sources.

Lead levels exceeding rural values have been measured in lichens in the vicinity of Belledune, Saint John, and Dalhousie. Substantially elevated lead levels in lichens in the vicinity of Belledune in 1982 were attributed in part to airborne emissions of the lead smelter. Lead deposition to vegetation in the Belledune area in 1980 and 1981 was also related to smelter emissions. In studies carried out from 1978 to 1982, elevated lead levels in the Saint John area were linked primarily to the combustion of leaded fuels by the transportation sector. The cause of elevated lead in lichens detected during a 1977 to 1980 study in the Dalhousie area is unknown due to the coincidence of geological and anthropogenic sources of lead.

A more detailed description of the moss and lichen studies is attached in Appendix 3.

The Department also carried out two small studies to examine the effects of acid rain (low pH) on the leaching of heavy metals from groundwater and piping systems. One study involved stand tests in a pipeline system at Musquash, near Saint John. Evidence of leaching was detected, however, lead values were not above the Canadian Drinking Water Guidelines (>0.05 mg/l). The groundwater study was conducted in the Welsford area. The natural low pH of the groundwater from this area did not raise the lead concentration above the Canadian Drinking Water Guidelines.

SOURCES OF LEAD INFORMATION

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APPENDIX 1
(A. P. Jaques, 1985)

TABLE 1 LEAD EMISSION FACTORS

Sector	Pb Emission Factor	
Mining, Milling & Concentrating		
Mining - Open Pit	1.025	kg/tonne Pb processed
- Underground	1.0125	kg/tonne Pb processed
Milling & Concentrating	1.45	kg/tonne Pb processed
Primary Lead/Zinc Production	1.73	kg/tonne Pb refined
Primary Copper/Nickel Production	(0.86-16.7)	kg/tonne production
Secondary Lead Smelting	0.2	kg/tonne Pb processed
Brass & Bronze Foundries	0.23	kg/tonne ingots processed
Metal Fabricating Industries		
Solders	0.13	kg/tonne Pb consumed
Alloys, Cables, Metal Fabrication	2	kg/tonne Pb consumed
Metallurgical Coke Manufacture	(0.3-1.33)	g/tonne coal consumed
Primary Iron Production		
Iron Sintering	15	kg/tonne particulates
Blast Furnace	0.2	kg/tonne particulates
Electric Furnace	15	kg/tonne particulates
Primary Steel Production		
Basic Oxygen Furnace	14	kg/tonne particulates
Open Hearth Furnace	6	kg/tonne particulates
Electric Arc Furnace	29	kg/tonne particulates
Ferroalloys	0.053	kg/tonne production
Cement	(0.2-3)	g/tonne cement produced
Ferrous Foundries	0.18	kg/tonne metal melted
Lead Glass Production	0.013	kg/tonne silica sand consumed (average)
Storage Battery Production	8	kg/1000 batteries produced
Lead Alkyl	2.9	kg/tonne TEL produced (average)
Lead Oxides & Pigments Production	0.5	kg/tonne pigment consumed
	0.065	kg/tonne litharge produced
Fuel Combustion/Stationary Sources		
Coal	(0.02-1.25)	g/tonne coal consumed
Heavy Oil	1.25	mg/litre of oil consumed
Light Oil	0.125	mg/litre of oil consumed
Gasoline Powered Vehicles	0.750	kg/kg Pb in gasoline consumed
Solid Waste Incineration		
Municipal refuse	(0.002-2.5)	g/tonne refuse
Sewage Sludge		
Multiple Hearth	0.015	kg/tonne sludge
Fluidized Bed	0.00125	kg/tonne sludge
Waste Oil	48	mg/litre oil
Gasoline Marketing	1.84	g/1000 litres (average)

TABLE S.1 SUMMARY OF EMISSIONS OF LEAD IN 1982 (tonnes)

Sector	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Terr.	Canada	% of Total
Industrial Processes:													
Mining, Milling & Concentrating of Lead-Bearing Ores	8		29	281		31	4			259	352	964	8.42
Primary Lead/Zinc Production				59			76			169		304	2.66
Primary Copper/Nickel Production					1194	205	305			2		1706	14.88
Secondary Lead Smelting Industry					5	7	1		< 1	< 1		14	0.12
Brass & Bronze Foundries				14	< 1	1				< 1		16	0.14
Metal Fabricating Industries	< 1		< 1	< 1	18	42	2	< 1	5	5		75	0.65
Metallurgical Coke Production			< 1			2	< 1	< 1		< 1		2	0.02
Primary Iron & Steel Production			36		238	226	12	64	10	14		600	5.23
Ferroalloy Production					14							14	0.12
Ferrous Foundries (1980)			< 1	< 1	34	172	< 1		3	2		212	1.85
Cement Manufacture	< 1		< 1	< 1	3	< 1	< 1	< 1	< 1	< 1		6	0.05
Leaded Glass Production				< 1	3	5			< 1	1		10	0.09
Lead Alkyl Manufacture						42						42	0.37
Storage Battery Production			< 1		2	15	1		1	1		20	0.17
Lead Oxides & Pigment Production	< 1		< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		1	0.01
Tar Sands Operations									20			20	0.17
Fuel Combustion - Stationary Sources:													
Power Generation	< 1	<1	2	1	< 1	4	< 1	3	3	< 1	< 1	14	0.12
Industrial Fuel Combustion	< 1	<1	< 1	< 1	3	2	< 1	< 1	< 1	1	< 1	8	0.07
Commercial Fuel Combustion	< 1	<1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2	0.02
Residential Fuel Combustion	< 1	<1	< 1					< 1	< 1			1	0.01
Fuel Combustion - Transportation Sources:													
Gasoline Powered Motor Vehicles	100	30	190	170	1390	2230	350	490	1120	910	20	7000	61.05
Aircraft	3	2	6	1	21	39	20	11	28	29	13	173	1.51
Solid Waste Incineration:													
Municipal Refuse Incineration					36	23		1		7		67	0.58
Sewage Sludge Incineration						2				< 1		2	0.02
Waste Oil Incineration	5	2	7	10	53	53						130	1.13
Miscellaneous Sources:													
Gasoline Marketing	1		4	2	23	11	2	7	7	6		63	0.55
TOTALS	118	34	276	541	3038	3113	775	578	1199	1408	386	11 466	100.00

APPENDIX 1
(A.P. Jaques, 1985)

TABLE 5.2 SUMMARY OF LEAD DISCHARGED IN EFFLUENTS IN 1982 (tonnes)

Sector	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Terr.	Canada	% of Total
Mining and Milling	1		< 1	38	4	1	1	<1		3	1	49	9
Smelting and Refining					2	3	< 1		< 1	23		29	5
Metal Plating					5		< 1		< 1			5	1
Storage Battery Manufacture			< 1		< 1	3	< 1		< 1	< 1		4	< 1
Primary Iron and Steel			< 1		3	3	< 1	1	< 1	< 1		9	2
Metal Fabrication						1			< 1	< 1		2	< 1
Foundries						< 1						< 1	< 1
Chemical Manufacturing					6	26		<1		4		37	7
Pulp and Paper Mills					8			1				9	2
Refineries			< 1		< 1	< 1	< 1	<1	< 1	< 1	<1	2	< 1
Municipal Sewage	16	<1	19	8	221	86	8	6	18	29	1	412	73
Miscellaneous					< 1			<1	2	2		4	1
TOTALS	17	<1	20	46	250	125	10	9	21	62	2	562	100

APPENDIX 2
(DMAE, 1985 from BM&S Data)

BRUNSWICK MINING AND SMELTING CORPORATION LIMITED
SMELTING DIVISION

MONTHLY AVERAGES — HIGH VOLUME AIR SAMPLING (1.13 std M3/min)
ug/m3/24 hr.

#1 "AIRSTRIP"	*S/P	PB	CD	AS	SO4
ONTARIO LIMIT	120	5.0	2.0	25	
JANUARY	10.594	0.937	0.0618	0.0907	2.800
FEBRUARY	29.850	0.409	0.0102	0.0312	5.220
MARCH	23.350	1.653	0.0368	0.0942	4.880
APRIL	37.100	1.412	0.0268	0.0862	7.140
MAY	36.778	0.814	0.0180	0.0541	8.133
JUNE	26.500	1.806	0.0314	0.0505	3.385
JULY	39.200	0.740	0.0112	0.0267	6.600
AUGUST	14.900	0.562	0.0061	0.0382	3.363
SEPTEMBER	16.433	0.337	0.0101	0.0328	2.773
OCTOBER	17.577	0.236	0.0084	0.0876	3.687
NOVEMBER	10.593	0.262	0.0159	0.0196	1.938
DECEMBER	16.585	0.145	0.0015	0.0106	1.920

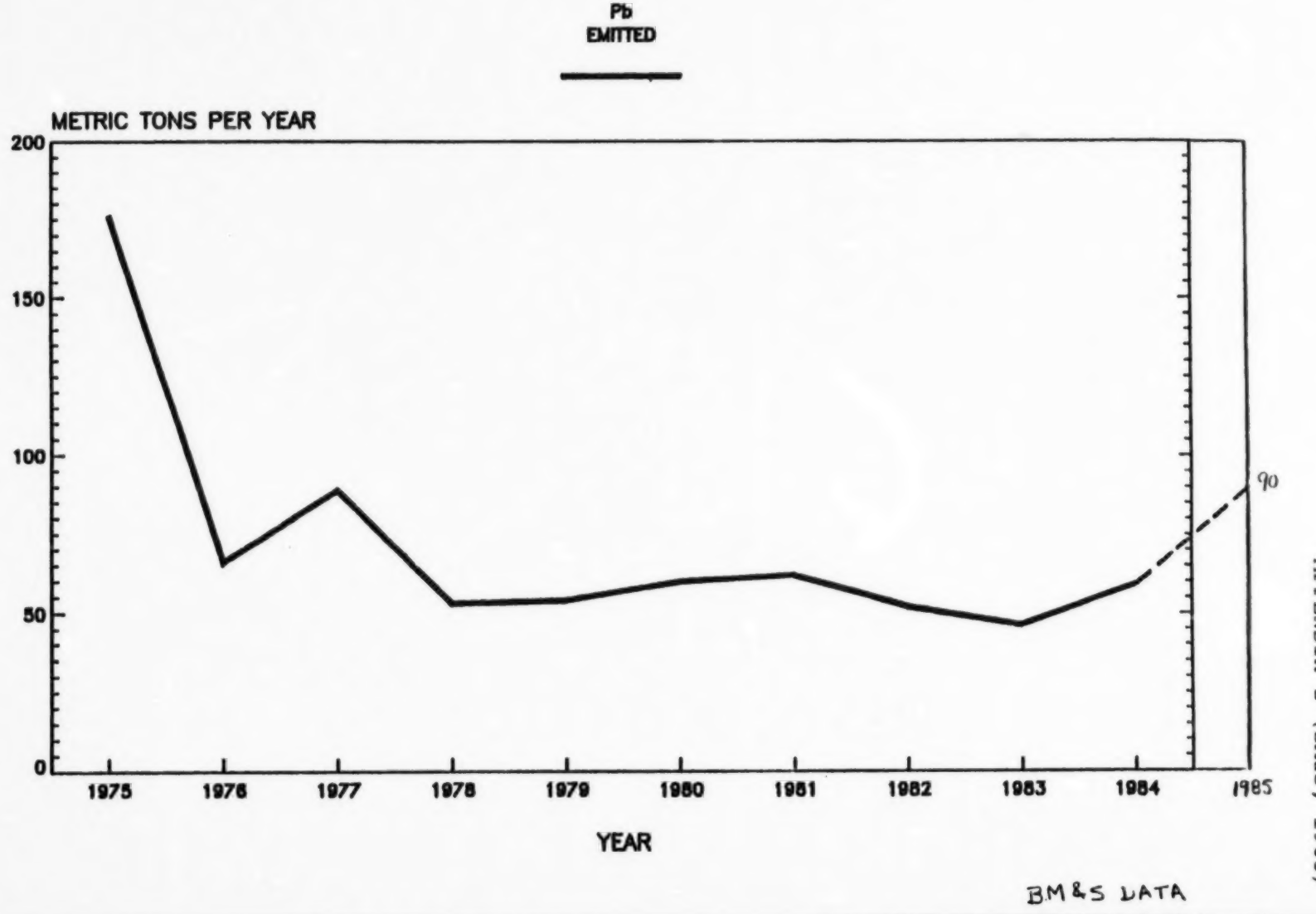
#2 "TOWNSITE 2"	*S/P	PB	CD	AS	SO4
JANUARY	6.606	0.035	0.0007	0.0047	1.300
FEBRUARY	20.775	0.162	0.0048	0.0159	3.670
MARCH	7.633	0.035	0.0008	0.0116	1.420
APRIL	15.827	0.216	0.0068	0.0205	3.260
MAY	11.813	0.559	0.0406	0.0551	3.773
JUNE	9.200	0.487	0.0265	0.0778	2.175
JULY	7.242	0.282	0.0102	0.0367	1.047
AUGUST	11.095	0.169	0.0048	0.0158	1.788
SEPTEMBER	10.107	0.258	0.0125	0.0475	1.818
OCTOBER	11.343	0.117	0.0065	0.0185	3.553
NOVEMBER	4.490	0.062	0.0044	0.0065	1.027
DECEMBER	6.345	0.025	0.0006	0.0050	1.141

#3 "CHALMERS"	*S/P	PB	CD	AS	SO4
JANUARY	3.726	0.055	0.0007	0.0043	0.800
FEBRUARY	25.800	0.400	0.0097	0.0298	4.320
MARCH	11.573	0.472	0.0177	0.0317	2.630
APRIL	25.167	1.207	0.0258	0.0629	6.010
MAY	17.360	0.929	0.0261	0.1158	5.180
JUNE	12.248	0.412	0.0241	0.0386	2.091
JULY	19.275	0.586	0.0207	0.0498	2.75
AUGUST	7.790	0.160	0.0024	0.0074	1.49
SEPTEMBER	11.517	0.261	0.0050	0.0236	2.27
OCTOBER	14.650	0.224	0.0091	0.0242	3.03
NOVEMBER	15.587	0.133	0.0035	0.0079	2.52
DECEMBER	10.840	0.370	0.0083	0.0422	2.10

Monitoring Stations - 1.0-1.5 km from smelter

* Suspended Particulates

SUMMARY OF SMELTER AIR EMISSION
1975–1984



APPENDIX 2 (BM&S, 1985)

APPENDIX 2
(after BM&S, 1984)

COMPARISON OF ESTIMATED YEARLY EMISSIONS THROUGH STACKS IN 1983 AND 1984

BASED ON ACTUAL PLANT AVAILIBILITY)

STACKS	KILOGRAMS					
	LEAD		CADMIUM		ARSENIC	
	1983	1984a	1983	1984a	1983	1984a
Acid Plant	-	-	-	-	-	-
Sinter P-50	40	67	6	1	2	21
P-52	32	32	5	3	2	63
P-27	4713	8366	223	285	203	630
Baghouse	17683	26591	600	291	600	692
Furnace Slag Baghouse	2957	1609	117	177	325	190
Furnace Main Baghouse	16854	18893	2610	2180	3153	3730
Pb Refinery Baghouse	764	3550	4	20	55	256
Total	43043	59098	3565	2957	4340	5582

[a] 1984 actual plant availability as of August 1984 (Sinter 89.5%, Furnace 84.1%, Lead 95%)

APPENDIX 2
(B.M.W. Carroll, 1985)

Table 7

NEW BRUNSWICK MINERAL PRODUCTION
1984

(Preliminary Estimate)

	Units	Quantity	$ Value
METALS			
Antimony	kg	-----	827,000
Bismuth	kg	159,000	1,879,000
Copper	kg	7,186,000	13,631,000
Gold	g	502,000	7,573,000
Lead	kg	73,250,000	53,890,000
Silver	kg	136,000	47,704,000
Tungsten	kg	-----	12,000,000
Zinc	kg	246,424,000	346,719,000
TOTAL			484,223,000
NON-METALLICS			
Peat	t	145,000	12,831,000
Potash	t	-----	19,784,900
*Silica	t	-----	1,250,000
Salt	t	-----	7,457,538
Sulphur, in smelter gas	t	119,000	7,827,000
TOTAL			49,150,438
FUELS			
Coal	t	575,640	30,300,000
Natural Gas	m^3	2,000	28,000
Petroleum Crude	m^3	-----	15,000
TOTAL			30,343,000
STRUCTURAL MATERIALS			
Clay products		-----	3,550,000
Cement	t	-----	9,676,000
Lime	t	-----	5,506,000
Sand and Gravel	t	5,410,000	10,275,000
Stone	t	2,005,000	10,940,000
TOTAL			39,947,000
GRAND TOTAL 1984 (Preliminary)			$603,663,438

*Formerly reported as "Quartz".

APPENDIX 3
(J. Tims, 1986)

Lead in the New Brunswick Environment: Biomonitoring With Lichens and Mosses

Prepared by Jane Spavold Tims
as part of a Departmental Submission to
the Royal Society of Canada
Commission on Lead in The Environment

February, 1986

Lichens and mosses, because of their simple tissue organization, and their tendency to retain and accumulate ions, are frequently used to study deposition and effects of local airborne pollutants, including lead (Richardson and Nieboer, 1981).

Data on lead in lichens and mosses in New Brunswick are available from several studies which have used plants as monitors of airborne pollutants. These include biomonitoring done by the New Brunswick Department of Municipal Affairs and Environment. Selected plants are collected from natural habitats in the vicinity of local airborne trace metal emissions, and their tissues are analysed for trace metals. Species typically used in these monitoring efforts are the lichens Cladina rangiferina, C. arbuscula, C. stellaris, C. mitis, and Cladonia uncialis and the mosses Sphagnum fuscum and S. magellanicum.

Trace metal deposition rates to vegetation have been measured using the technique of deploying moss bag air samplers for specific time periods and measuring the uptake of metals by exposed Spagnum mosses (Temple et al., 1981).

It is desirable to correct for the presence of trace metals contributed by wind-blown crustal materials when interpreting lichen and moss tissue analysis data. Correction is done by calculating "enrichment factors" which compare the relative levels of a given metal and a "reference metal" (for example, aluminum) in plant tissue and crustal material (Puckett and Finegan, 1980). Theoretically, when samples are enriched from crustal sources only, the enrichment factor is 1.0. When enrichment factors exceed unity, plant tissues are said to be enriched with respect to background, by anthropogenic or other sources. It is this "anthropogenic enrichment" which is of interest in these studies.

Interpretation of enrichment factors must take into account the fact that the metal concentrations used in the calculations are of "generalized North American" rock (Puckett and Finegan, 1980). In an area such as northern New Brunswick, high enrichment factors are expected due to the influence of windblown dusts originating from metal-rich ore deposits. High enrichment factors may, therefore, indicate natural crustal rather than anthropogenic enrichment.

Lead in Lichens and Mosses in Rural Areas of New Brunswick

In 1984, the Department of Municipal Affairs and Environment began a study to measure trace metal deposition to vegetation in rural areas of New Brunswick. Three species of Cladina and two species of Sphagnum were collected from ombrotrophic bogs (bogs in which mineral inputs are restricted to atmospheric sources) throughout the province, in areas distant from local air pollutant emissions.

The 1984 data showed that lead concentrations in lichens in rural New Brunswick ranged from 4.32 to 17.4 ppm with median values of 7.39 to 8.13 ppm. Enrichment factors ranged from 93.5 to 596.2. Zakshek et al. (1985a and b) found similar levels of lead in the lichen Cladina rangiferina in ombrotrophic bogs in New Brunswick and the rest of eastern Canada.

Lead levels in lichens in rural areas of New Brunswick were higher than those measured in remote regions of Canada. Lead levels in Cladina lichens collected in remote areas of Canada's Northwest Territories typically range from 1 to 12 ppm (Puckett, 1978; Puckett and Finegan, 1980). Enrichment factors for lead in arctic lichens range from 60 to 90, indicating that there is some anthropogenic enrichment of lead in vegetation even in these remote areas.

Lead concentrations in moss collected in rural New Brunswick ranged from 7.09 to 32.1 ppm, with median concentrations of 12.8 to 14.1 ppm. Enrichment factors ranged from 68.2 to 567.4 . Lead levels in the species Sphagnum magellanicum were 14.9 ppm ± 8.04 ppm (mean ± standard deviation); Percy (1983) reported levels of 9.38 ppm ± 7.38 ppm in this species in bogs in New Brunswick, Nova Scotia and Prince Edward Island.

These levels are generally above those reported for mosses in the remote arctic. Glooschenko and Capobianco (1978) reported mean lead concentrations in Sphagnum mosses in the Northwest Territories to be 8.00 ppm.

Enrichment of lead in lichens and mosses in rural New Brunswick may be due to long range transport of airborne lead pollution. In the northern part of the province in particular, it may also be associated with local geology.

In this study, the highest concentrations of lead in both lichens and mosses were found in a bog in the northeastern part of the province, an area containing mineral-rich geology, several metal mining operations and the Belledune lead smelter (see below). Percy (1983) also found lead enrichment in this area and indicated anthropogenic emissions as a possible cause.

Lead in Lichens in Northern New Brunswick

1) The Belledune Regional Bioindicator Study

The Belledune Regional Bioindicator Study was begun in 1980 for the purpose of determining the deposition patterns and loadings of several trace metals, including lead, to vegetation in the vicinity of the lead smelter at Belledune.

Lichens collected within 31 km of the lead smelter in 1982 showed lead values ranging from 19.1 to 101.0 ppm, with a mean of 49.9 ppm, subtantially elevated with respect to levels in rural New Brunswick. Elevated concentrations occurred at sites near to the smelter. There was also a significant negative correlation between lead concentration and distance from the smelter for the species Cladina stellaris.

Enrichment factors for lead ranged from 368.3 to 2079.3.

In moss bag air sampler deposition experiments in 1980 and 1981, lead deposition was significantly negatively correlated with distance from the smelter. Mean monthly deposition rates of lead were .11 (.13 kg/ha/yr) and .25 µg/cm2 (.30 kg/ha/yr) for 1980 and 1981 respectively. The maximum monthly deposition recorded was 1.5 µg/cm2 (1.8 kg/ha/yr).

In addition to emissions from the lead smelter, possible sources

of airborne lead in the Belledune area include windblown crustal materials from ore-rich soils and rock, and emissions from the transportation sector.

2) The Dalhousie Thermal Generating Station Bioindicator Study

The Dalhousie Thermal Generating Station Bioindicator Study was begun in 1977 for the purpose of determining patterns and levels of deposition of several trace metals, including lead, to vegetation.

Lead data are available for three species of the lichen Cladina from 1977 through 1980 at sites within 80 km of the thermal generating station. Lead concentrations in these samples were generally higher than those at rural locations, and ranged from 4.4 to 56.0 ppm, with median values from 15.0 to 24.0 ppm. Enrichment factors consistantly showed enrichment of lead with respect to rural areas. Lead appeared to increase slightly during the four years of study. Sites near to Dalhousie showed elevated lead levels with respect to levels measured at control sites. At present the relative contributions of the generating station emissions, emissions from transportation sources and crustal inputs from metal deposits in the chain of hills immediately to the south of the station are unknown.

Lead in Lichens in Southern New Brunswick

1) The Grand Lake Thermal Generating Station Bioindicator Study

Lichen collections were made in 1979 in the vicinity of the Grand Lake Thermal Generating Station at Minto to determine patterns and levels of deposition of a variety of trace metals, including lead, in relation to the plant operations.

Lichens collected within 40 km of the generating station showed median lead levels of 11.0 to 13.0 ppm, only slightly above levels typical of remote areas and similar to levels measured in rural New Brunswick. Lead concentrations were not related to distance from the thermal generating station. Enrichment factors are not available for the study.

2) The Saint John Regional Bioindicator Study

Lead has also been measured in lichens in the vicinity of Saint John, where several industries and utilities are located, including two thermal generating stations and an oil refinery. Data were collected as part of a long term study to characterize trace metal loadings in the Saint John area.

Lead data are presently available for five species of Cladina for the years 1978, 1979, 1980 and 1982. Lead concentrations for all species and all years ranged from 5.2 to 158.0 ppm, with median

values ranging from 11.6 to 52.7 ppm, generally above levels measured in rural parts of the province. Enrichment factors ranged from 21.4 to 679.6 with median values from 177.1 to 466.9. These values are similar to those reported for the Saint John area by Puckett and Finegan (1977). There was no conclusive indication of an increase in the mean concentration of lead during the period of study. High lead concentrations were usually associated with proximity to major roads. In 1978 there was a significant negative correlation between lead concentration in lichen tissues and distance from the city. Puckett and Finegan (1977, 1981) indicated that lead levels in lichen samples collected in 1976 in the Saint John area were related to the combustion of leaded fuels.

Summary

Airborne lead has been measured by the New Brunswick Department of Municipal Affairs and Environment in several studies designed to determine patterns and levels of trace metal deposition to vegetation in the vicinity of point and area sources of airborne pollutants.

In a 1984 study, levels of lead in lichens and mosses in rural New Brunswick were elevated with respect to levels in arctic lichens and mosses, perhaps due to long range transport of airborne lead. Lead levels in northern New Brunswick may be elevated in part due to the presence of geological sources.

Lead levels exceeding rural values have been measured in lichens in the vicinty of Belledune, Saint John, and Dalhousie. Substantially elevated lead levels in lichens in the vicinity of Belledune in 1982 were attributed in part to airborne emissions of the lead smelter. Lead deposition to vegetation in the Belledune area in 1980 and 1981 was also related to smelter emissions. Elevated lead levels in the Saint John area in studies from 1978 to 1982 were linked primarily to the combustion of leaded fuels by the transportation sector. The cause of elevated lead in lichens in a study in the Dalhousie area from 1977 to 1980 is unknown due to the geographical coincidence of geological and anthropogenic sources of lead.

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